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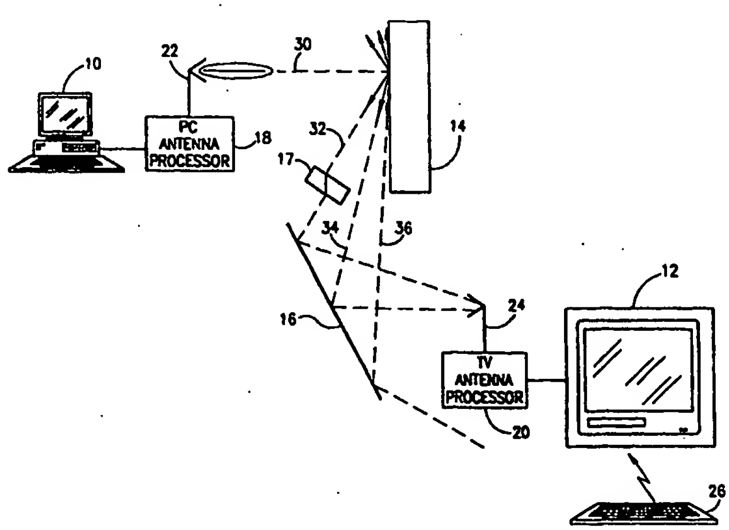

(57) Abstract

A system for providing the output of a computer to a television set via wireless channel within a building is provided. The system includes a transmission antenna unit, a transmission processor, a reception antenna unit and a reception processor. The transmission processor is connected between the computer and the transmission antenna unit and converts the computer output to a composite video signal, upconverts the composite video signal to a carrier frequency not within a range reserved for television transmissions and provides the upconverted signal to the transmission antenna for transmission within the building. The reception antenna unit has at least one set of two, differently polarized reception antennas and receives the transmitted signal. The reception processor processes and combines the output of the two antennas of each set and adapts the processing in accordance with the quality of the output.

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APPARATUS FOR WIRELESS TRANSFER OF VIDEO FROM A COMPUTER TO A TELEVISION SET

FIELD OF THE INVENTION

The present invention relates to the high-quality wireless transfer of composite video information from a computer to a television set. More specifically, it applies to situations of severe multi-path propagation due to reflections, as is common in indoor propagation.

BACKGROUND OF THE INVENTION

Television sets are extremely common, and typically receive a television signal in one of several standard formats. The reception is either over a wire, as in cable systems, or over a wireless channel via an external antenna, be it a roof-top directional antenna aimed at the transmission antenna or a satellite dish. In either case, the signal quality is usually high and, most important, is not subject to the effects of indoor wireless propagation. Yet another option entails the use of a set-top antenna, but this typically results in poor reception quality, "ghosts" on the screen , etc.; such an arrangement is clearly inferior to the two previous ones, and is typically used only in the absence of a better alternative.

The advancement of technology and reduction in prices of computer hardware and software over the recent years have led to the proliferation of computer equipment in homes. The primary use of computers was initially for word processing and computing. More recently, Internet browsing has become the predominant use of computers in homes (in terms of time spent at the computer). Presently, there is an increasing trend to also use the computer for real-time (interactive) communications, such as for Internet phones and for video conferencing. Another recent trend is toward digital versatile disks (DVDs) which are a new type of storage device. DVDs have so much storage that they can store an entire movie, thereby possibly replacing the video cassette recorder (VCR).

The aforementioned shift in computer usage in the home has naturally been accompanied by a change in the social environment in which it is used: whereas the natural setting for word processing is at a desk in a study, the natural setting for a video conference with the family, for playing games over the network, for browsing through the Internet in search of a good restaurant and for watching a movie with a DVD is in the den or living room.

Unfortunately, the computer is in the study. However, there is often a television set with a larger screen in the den or living room. The problem is how to exploit all or part of the resources for the new uses of the computer in the most convenient setting.

One approach, as exemplified by the "WebTV" product of WebTV Corporation of California, USA, is to create a special-purpose apparatus that is deployed in the same room as the TV set and uses the TV set as monitor and speakers. The special apparatus provides the user with a keyboard, mouse, etc., but the actual "computer" belongs to a service provider and is outside the home. This approach is viable, but suffers from several important shortcomings.

One important shortcoming of this approach is that it is merely a "front end" for a service provider. Specifically, external communication is required even from the location of the television set in order for the system to be usable at all. Furthermore, the service provider determines the functionality that is available on the system and there is no local storage. The latter disadvantage is best exemplified by the fact that any new storage device can easily be added to existing computers, they are an impractical or impossible addition to a custom device such as a WebTV.

Yet another shortcoming is the inability to communicate between the home computer and the WebTV other than via the service provider, typically via a slow link and in any case at the discretion of the service provider. For example, entering a newly-discovered (over the web) restaurant into the personal restaurant database on the main home computer, or printing out information, is impossible. Finally, this approach is non-standard, making the user a captive customer of the vendor of his "TV computer".

In view of the above shortcomings, the preferred approach is to enable the collaborative use of a standard computer and a standard television set, thereby making the computer resources available at the most desirable setting for any application. (This approach does not prevent the use of the services of a service provider, with the connection done from the main home computer. However, this would not be mandated and would only be done as necessary or desired by the user.) The most challenging problem to this end is carrying the high-bandwidth signal containing the video and audio information from the computer to the television set and, possibly, in the other direction.

The simplest way of carrying the desired signal is through an appropriate cable connecting the computer with the television set. However, this is impractical in many situations due to the aesthetic ramifications of installing a cable through a furnished home.

Alternatively, a wireless channel can be constructed between the two rooms. To do so, a standard composite television signal is created at the PC, its carrier frequency is shifted to a permissible range and the result is transmitted. At the television set, the received signal's frequency is then shifted to one of the standard television channel frequencies and supplied to the television set. This approach, exemplified by the V900SX product of Recoton of Florida, USA and WaveCom by RF-Link Systems of Taipei, Taiwan, is extremely limited in range and is highly susceptible to any imperfections in the signal-propagation environment. The range limitations stem, in part, from regulatory constraints that severely restrict the transmission power, but both they and the inconsistent signal quality stem from propagation phenomena such as reflections, multi-path interference, and polarization distortion due to the numerous obstacles in the signal path in a typical home.

A similar product by Dynapix of California, USA is again susceptible to propagation problems, and the manufacturer, in fact, warns the user that the reception is extremely sensitive to antenna positioning. Such problems may very well render the whole approach non-viable in the view of most customers.

Another approach entails the use of wireless infrared links. However, such links require line of sight. Therefore, one must form a succession of straight-line links, each of which is unobstructed. This can be done by a sequence of such links, interconnected by wire segments with active repeaters. However, this is expensive and complicated, requiring the supply of power to the intermediate repeaters. An alternative approach is to use a sequence of passive optical reflectors (mirrors) to direct the optical signal along a zig-zag path from source to destination. While the reflectors themselves may be quite inexpensive, the need to locate them at particular places may both be expensive and have unpleasant aesthetic consequences.

Yet another approach is to modulate the signal onto the mains (power) lines within the home, thereby reaching the desired room, and to either use very short range wireless links between a mains outlet in each room and the respective equipment (computer or television set) or use wires for this purpose. This approach attempts to overcome the wiring problem, but its quality is unreliable and it is susceptible to interference by equipment connected to the mains line.

US Patents 5,410,735 and 5,272,525 discuss computer to television systems such as described hereinabove.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a wireless link for carrying high bandwidth signals, such as video and audio signals, within a home without requiring line of sight. Typically, the link would be used between a computer (typically) located in one room and a television set (typically) located in a different room or vice versa.

There is therefore provided, in accordance with a preferred embodiment of the present invention, a system for providing the output of a computer to a television set via wireless channel within a building. The system includes a transmission antenna unit; a transmission processor, a reception antenna unit and a reception processor. The transmission processor is connected between the computer and the transmission antenna unit and converts the computer output to a composite video signal, upconverts the composite video signal to a carrier frequency not within a range reserved for television transmissions and provides the upconverted signal to the transmission antenna for transmission within the building. The reception antenna unit has at least one set of two, differently polarized reception antennas and receives the transmitted signal. The reception processor processes and combines the output of the two antennas of each set and adapts the processing in accordance with the quality of the output.

The reception processor includes means for measuring the quality during non-image periods and for adapting the processing when necessary.

Additionally, in accordance with a preferred embodiment of the present invention, the transmission antenna can be a multi-polarization antenna, a single polarization antenna or a steerable polarization antenna.

Further, in accordance with a preferred embodiment of the present invention, the steerable polarization antenna includes a first antenna polarized in a first direction which directly transmits the upconverted signal, a controllable processor which provides at least one of amplification and phase shifting to the upconverted signal and a second antenna polarized in a second direction other than the first direction which transmits the output of the processor. The amount of

the relative phase shift and relative amplification can be changed thereby to change the polarization direction of the combined signal transmitted by the pair of antennas.

Still further, in accordance with an alternative preferred embodiment of the present invention, the steerable polarization antenna includes a multiplicity of first antennas lying in a first plane, a multiplicity of second antennas lying in a second plane and a selector. Each first antenna has a different polarization direction within the first plane. Each second antenna has a different polarization direction within the second plane. The selector selects one of the first antennas and one of the second antennas thereby to define a polarization direction. The upconverted signal is transmitted through the selected first and second antennas.

Moreover, in accordance with a preferred embodiment of the present invention, the reception processor includes one adaptable antenna processing unit per set of reception antennas, a downconverter and a quality feedback unit. Each adaptable antenna processing unit has a control unit for controlling the relative phase shift and relative attenuation between the output of each reception antenna and one combiner for combining the processed output of the antenna set. The downconverter converts the output of at least one of the combiners to a television signal to be provided to the television set. The quality feedback unit measures the quality of the television signal and selects control values for the control unit accordingly.

Finally, in accordance with a preferred embodiment of the present invention, the quality feedback unit includes input units for receiving quality definitions from a user.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description taken in conjunction with the appended drawings in which:

Fig. 1 is a schematic illustration of a system for transmitting, within a building, video signals from a computer to a television set, constructed and operative in accordance with a preferred embodiment of the present invention;

Fig. 2 is a schematic illustration of the transmission system useful in the system of Fig. 1;

Fig. 3 is a schematic illustration of a multipolarization antenna useful in the system of Fig. 1;

Figs. 4A and 4B are schematic illustrations of a reception system useful in the system of Fig. 1;

Fig. 5 is a flow chart illustration of the operation of a quality control loop, useful in the system of Fig. 1;

Fig. 6 is a graphical illustration showing one method for measuring the quality of a signal, useful in the method of Fig. 5;

Fig. 7 is a block diagram illustration of a unit for measuring the rise time of the signal in Fig. 6;

Fig. 8 is a schematic illustration of a wireless input unit;

Fig. 9 is a schematic illustration of an alternative transmission system useful in the system of Fig. 1;

Figs. 10A and 10B are schematic illustrations of an alternative reception system useful in the system of Fig. 1;

Fig. 11 is a schematic illustration of a steerable polarization antenna useful in the system of Fig. 1;

Fig. 12A is a schematic illustration of an alternative steerable polarization antenna; and

Fig. 12B is a schematic illustration of a selector useful in controlling the antenna of Fig. 12A.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

The invention relates to the transmission and reception of an analog high-bandwidth composite video signal from a computer to a television set through a medium, such as a building, that typically does not offer line of sight between transmitter and receiver.

Reference is now made to Fig. 1 which illustrates the system of the present invention within a building. The system includes a computer 10, such as a personal computer (PC), a television 12 between which are a blocking wall 14, a reflective wall 16 and a refractive wall 17. The system also includes a PC antenna signal processor 18 and a TV antenna signal processor 20, both for controlling the operations of their respective antennas 22 and 24. Finally, the system includes a wireless input unit 26 with which a user provides his input to the computer 10.

It is noted that wireless channels which carry a small bandwidth of information are known in the art and function well in buildings. Therefore, the transmission of the input signal will not be described. The problem discussed herein is the transmission of high bandwidth video signals under minimal power, as required by the Federal Communication Commission (FCC) of the USA.

Typically, the walls 14, 16 and 17 of the building severely affect the transmitted signal, labeled 30, resulting in multiple copies of the signal. Fig. 1 shows three copies, labeled 32, 34 and 36, all of which differ in the polarization, intensity, phase and angle at which they arrive to the reception antenna 24.

A signal transmitted indoors in one or more directions undergoes an unpredictable sequence of reflections, refractions, scattering and diffraction as it goes through or is redirected by various obstacles and materials. For example, wall 14 causes diffraction, wall 16 minimally causes reflection and wall 17 causes refraction. As a result, the signal arriving at the receiver antenna comprises a set of signals, some of which may have gone through different paths, and thus arrive after different delays, some of whose phase is altered due to reflections or other phenomena, and all of whom have different amplitudes.

For example, a signal that was originally transmitted with vertical linear polarization may go through a material that attenuates signals differently depending on their polarization. If the material is not aligned with the polarization of the original signal, the result is a signal with a linear polarization different than that of the original signal. If different components of the transmitted signal undergo different phase changes, the result is generally a signal with elliptical polarization, a special case of which is circular polarization. A combination of the two phenomena can result in a linearly-polarized component and an elliptically-polarized one.

Unfortunately, the various effects on the signal are a function of the type of walls in the building, their placement within the building and, more importantly, the relative placement of the computer 10 and television 12. Some relative locations within the building cause greater disturbance to the signals than others.

Since antennas are generally built to have a single polarization, if the changes in polarization of the transmitted signal are such that the polarization is completely changed, it is possible that an antenna placed in the wrong position might not receive any signal.

The present invention attempts to remain operative no matter where the transmission and reception antennas are placed. As discussed hereinbelow, the present invention, however, utilizes a combination of transmission and reception antennas that, together, attempt to ensure that some signal is successfully received despite the possibly poor and/or unpredictable transmission conditions of the building.

Reference is now made to Figs. 2, 3, 4A and 4B which illustrate one embodiment of the system of the present invention. Fig. 2 details the elements of the transmission system, Fig. 3 illustrates an exemplary transmission antenna 22 and Figs. 4A and 4B detail the elements of the reception system.

Specific reference is now made to Fig. 2, in which the computer 10 produces an output signal which includes the audio and video signals that normally go to the speakers and computer monitor, respectively. PC antenna signal processor 18 prepares the output signal for transmission through the

antenna 22. It includes a TV output generator 40, an upconverter 42 and a carrier frequency setter 44.

The TV output generator 40 produces a TV output signal from the output of the computer 10. Upconverter 42 shifts the carrier frequency to the frequency defined by setter 44, where the carrier frequency is determined by signal quality and regulatory considerations. For the United States, the unlicensed bands are around 900MHz, 2.4GHz, 5GHz and 24GHz.

The TV output generator 40 includes an RGB to TV unit 46 and a TV modulator 48. The computer video signals for the different colors are fed into the RGB to TV unit 46 which combines them to form a composite video signal, for example in a standard format such as NTSC or PAL. The composite video signal and the audio signal are fed into the TV modulator 48, which combines them to form a composite television signal. The modulator 48 also provides synchronization pulses known as frame sync. and line sync. The synchronization signals are provided to the frequency setter 44.

While the description herein refers to standard modulation techniques, the current invention is equally useful in conjunction with numerous other techniques. Such techniques may, for example, entail spectral conditioning of the signal in order to enhance reception or comply with regulations.

Exemplary TV output generators 40 are the PC2TV chip from ATI of Vancouver, Canada and the CL-GD5425 card from Cirrus Logic of Fremont, California, USA. Alternatively, some computers have a TV output port. For such computers, the TV output generator 40 is a part of the computer itself.

The composite signal is fed to upconverter 42 whose main components are a voltage controlled oscillator (VCO) 50, a mixer 52 and bandpass filters 54 and 56. Upconverters are well known in the art and, therefore, upconverter 42 will be described only briefly. The frequency of oscillation of the VCO 50 determines the amount by which the signal frequency will be shifted. The mixer 52 performs the shift, and filter 54 filters the composite signal prior to its shifting in order to reduce the undesirable spectral sidelobes of the signal. The mixed signal is then

further filtered by filter 56. The filtered output of the mixer is fed to an amplifier 58, whose output is connected to antenna 22.

The frequency setter 44 sets the current carrier frequency of the transmitted signal. Similar to cordless telephones, the number of frequency ranges is limited and a new frequency range is manually or automatically chosen only if there is significant interference on the previous frequency range from other wireless devices in the building.

The frequency setter 44 includes an encoder 60 and a frequency controller 62. The encoder 60 defines the allowable frequency ranges and frequency controller 62 activates the VCO 50 in accordance with the current setting of encoder 60.

In accordance with a preferred embodiment of the present invention, if the frequency range must be changed, frequency controller 62 typically changes it during "dead" periods of the TV signal, such as the "blanking periods" which occur during the return time of the beam at the end of a frame or a during horizontal scan line. The intrinsic time-gaps in signal content of a television signal are thus exploited favorably. To this end, frequency controller 62 receives the sync outputs of the TV modulator 48.

As discussed hereinabove, the present invention attempts to provide a communication link for all or most possible locations of the computer 10 and television set 12, despite the shape and structure of the building. Accordingly, transmission antenna 22 can be any suitable type of antenna. In one embodiment, the antenna 22 is a single polarization antenna. Alternatively, antenna 22 can be a "multi-polarization" antenna having multiple, polarization directions.

For the single polarization antenna, the transmitted signal has one polarization direction. As discussed hereinabove, with reference to Fig. 1 the signal received at the reception antenna 24 is a collection of signals which have multiple polarization directions and which are phase shifted one from the other. As will be discussed hereinbelow, the TV antenna signal processor 20 can

compensate for these changes. However, the resultant signal may not have a high signal to noise ratio.

For a multi-polarization antenna, multiple signals are transmitted, each with different polarization directions. The reception antenna unit 24 will still receive a collection of multi-polarized signals; however, at least one of the signals should provide a relatively high signal to noise ratio. The multi-polarization antenna "spreads the bets" as to which polarization is most effective for the various relative locations of computer 10 and television 12. With the multiple transmission signals and multiple polarization directions, the computer 10 and television 12 can be placed at whatever locations the user decides is right for him or her and the locations can change. For each location, one of the multiple signals most probably will provide a successful transmission.

The multi-polarization antenna can be produced in any suitable way. For example, the multi-polarization antenna can be any antenna with poor cross-polarization. Alternatively, such as antenna can be formed of two or three orthogonal linearly-polarized antennas. For example, one antenna with linear, horizontal polarization and one antenna with linear, vertical polarization.

Fig. 3, to which reference is now specifically made, illustrates a further embodiment of a multi-polarization antenna. It comprises a conical monopole 70 whose tip 72 is connected to a ground plane 74. The spreading angle β should be larger than 120°. The ground plane 74 should be small relative to the wavelength of the transmitted signals. The antenna of Fig. 3 produces polarization in two orthogonal angular directions, known as φ and θ.

Figs. 4A and 4B, to which reference is now specifically made, together form a block diagram of a reception system, according to an embodiment of the invention, which is useful with the transmission system of Fig. 2.

In accordance with a preferred embodiment of the present invention, the reception antenna unit 24 typically comprises multiple antennas which are paired such that each pair includes at least one antenna 80 having a first polarization and another antenna 82 having a second, different polarization. The two types of antennas 80 and 82 provide polarization diversity and the multiplicity of sets of

antennas provide spatial diversity and directional adaptivity. The reception system also includes a antenna signal processor 84 and phase controller 86 per set of antennas, a combiner 88, a downconverter 90 and a quality control unit 92.

The antenna signal processors 84, phase controller 86 and combiner 88 are controlled by the quality control unit 92 to adaptively tune the received signal. Downconverter 90 converts the received signal to one which television set 12 can process and quality control unit 92 determines the quality of the received signal, thereby to change the operation of units 84, 86 and 88.

Reception antenna signal processors 84 can be any suitable unit which adjusts the relative phase shift and/or relative attenuation of the antennas connected thereto and which combines the results. For example and as shown in the drawings, antenna signal processors 84 each include an amplifier 94 and an attenuator 96 per antenna, a phase shifter 98 receiving the output of one of the attenuators 96 and a combiner 100 receiving the output of phase shifter 98 and the other attenuator 96. The attenuators 96 and phase shifter 98 receive an antenna control (ANTC) signal from the quality control unit 92.

To understand the operation of the reception antenna signal processors 84, assume that the signal which arrives at the reception antenna unit 24 is a single signal with unknown polarization. For example, the received signal might be a linearly-polarized signal whose vertical and horizontal components are $Kv*\sin(\alpha)*\cos(\omega t + \varphi)$ and $Kh*\cos(\alpha)*\cos(\omega t + \varphi)$, where α is the angle of polarization. If two antennas, one with vertical polarization and the other with horizontal polarization, are used to receive the signal, their outputs would equal (to within the same multiplicative constant) the expressions just listed. As long as $\cos(\alpha)$ and $\sin(\alpha)$ are either both positive or both negative, addition, by combiner 100, at the output of the two antennas captures all of the received power in a constructive manner. Similarly, if α is such that the signs of the sine and cosine differ, subtraction of the two outputs of the antennas captures all of the received power. Subtraction is produced by providing a negative attenuation or amplification to one of the attenuators 96 or by providing a 180° phase shift, via phase shifter 98, to one of the outputs. This is true regardless of any

multiplicative factors (amplification or attenuation) that are applied to the two output signal after they are transmitted from the respective antennas.

Next, consider the case of a received signal which is formed of multiple signals, one which is desired signal and one or more which are undesired signal(s). The undesired signals can be viewed as interference or noise affecting the desired signal. The reception antenna signal processors 84 adjust the output of the antennas in order to reduce the affect of the undesired signals.

Each signal has a horizontal component and a vertical component defined by the equations hereinabove; however, the polarization angles, amplitudes and phases are different for the two signals.

In one situation, the desired signal has a polarization angle α such that the signs of the cosine and sine are equal, and the undesired signal has a polarization angle α' such that the signs of the cosine and the sine are different from each other. If the outputs of the two antennas are added, the undesired signal will be partially canceled, since it requires subtraction for best reception.

Moreover, by properly choosing the relative attenuation of the outputs of the two antennas, the two (horizontal and vertical) components of the undesired signal can made to effectively cancel one another without affecting the desired signal. Thus, for linearly-polarized signals, the choice whether to add or subtract the outputs of the two antennas can be used to amplify the desired signal; moreover, in conjunction with variable attenuation, it is also possible to essentially eliminate the most problematic linearly-polarized interfering signal if its polarization angle is within a given 180° range.

For an elliptically-polarized received signal, the two components (H and V) are out of phase. In order to achieve the best constructive reception, it is important to add them in phase. Phase shifters 98 adjust the relative phases to offset the difference. Amplitude attenuation can again be employed to reduce the effect of undesired arriving signals.

The reception antenna signal processors 84 produce a tunable reception antenna, under control of quality control unit 92, which can effectively achieve polarization steering in the case of elliptically-polarized signals. Antenna signal

processors 84 enable the reception system of Figs. 4A and 4B to attempt to match the polarization of the desired signal. For a linearly-polarized arriving signal, the effect is slightly different: the decision whether to add or subtract the two signals provides a two-state polarization tuning, and the variable attenuation can be used to reduce the adverse effect of undesired signals whose polarization is in a different 180° range than that of the desired signal.

The output signals of the different reception antenna signal processors 84, corresponding to the received signals of different antenna pairs (each pair comprising antennas 80 and 82) are each provided to their corresponding phase controller 86, also under control of the quality control unit 92. Phase controllers 86 shift the phase of one or both of the output signals of the reception antenna signals processors 84 to have matching phases. The output signals of the phase controllers 86 are then fed to the combiner 88 which, under control of the quality control unit 92, merges the signals to achieve the effect of a directional antenna.

In an alternative embodiment, the phase controllers 86 and the subsequent combiner 88 are replaced by a selector that selects one of the signals. Since there are two or more sets of antennas, the antenna set in the currently best location can be selected. This is known as space diversity.

The signal at the output of the combiner 88 or, in the alternative embodiment, at the output of the selector, is fed to downconverter 90 which shifts the carrier frequency of the signal to a channel that can be received by the television set 12. As is known in the art, the downconverter contains a mixer 102, a tunable oscillator, such as a voltage-controlled oscillator 104, for determining the frequency shift, and bandpass filters 106 to prevent any undesirable spectral pollution.

The "PCTV" signal output of the downconverter 90 is then fed into a signal splitter 108 that allows most of the signal to continue into an antenna combiner 110 which feeds the signal along with a signal from a conventional TV antenna or cable system 112 to the television receiver 12. The carrier frequency of the PCTV signal coming out of the downconverter 90 differs from that of the signals coming from the conventional antenna 112 so that the PCTV signal does

not interfere with the conventional TV signals and, if desired, both the PCTV signal and the conventional TV signals can be viewed simultaneously on the screen of the television set 12. This is similar to the "picture in a picture" feature of some recent television sets.

The fraction of the signal that comes out of the port at the bottom of the signal splitter 108 is fed to quality control unit 92 for determination of the quality of the signal and for changing the control variables. If the signal quality is very low, the transmission frequency can also be changed. In accordance with a preferred embodiment of the present invention, quality control unit 92 measures the quality of the signal during the blanking periods of the signal (i.e. during the vertical and horizontal return of the electron beam of the television set), which transmit no information. Quality control unit 92 can change the control variables during the blanking periods or at any other suitable time during the transmission.

It will be appreciated that, due to the propagation delays of the different paths, the blanking periods begin at slightly different moments for each of the paths. For in-building propagation, these differences are extremely slight while for standard television propagation, which occurs over significant distances, the differences are much more significant. Since the differences are small for in-building propagation, the present invention utilizes the blanking period of the signal currently being provided to the television set 12.

Quality control unit 92 comprises a frequency shifter 120 (under control of a voltage controlled oscillator 121), a low pass filter 122, a sync separator 124, a microcontroller 126 and a frequency encoder 128.

The frequency shifter 120 removes the carrier frequency of the PCTV signal so as to recover the baseband composite video signal. The composite video signal is filtered by low pass filter 122 and is then fed into sync separator 124 which recovers the horizontal (line) and vertical (frame) synchronization signals and indicates their presence to the microcontroller 126.

Whenever so notified by the sync separator 124, the microcontroller 126 assesses the quality of the blank periods of the PCTV signal via methods described hereinbelow with respect to Fig. 5. If the quality is less than desired,

the microcontroller 126 changes the polarization direction as defined by the attenuation values, phase shift values and combination/selection of the antenna output signals. If the quality is very poor, the transmission frequency can also be changed: The microcontroller 126 typically attempts a variety of settings, assesses their quality and selects the current best setting for the next frame. As long as the quality stays above a desired level, the microcontroller 126 will make no further changes.

The microcontroller 126 specifies the attenuation levels of the different attenuators 96, the phase shifts of the phase controllers 98 and 86, and the selection to be made by the selector (in the relevant embodiment). The microcontroller 126 also selects the frequency shift of the downconverter 90, based on a frequency sequence generated by the encoder 128, to shift the carrier frequency of the transmitted signal to one which the television set 12 can receive. If the signal quality is so poor that the transmission frequency must change, microcontroller 126 indicates the new frequency range through an appropriate command (not shown) to the voltage controlled oscillators 50 (Fig. 2) and 121 (Fig. 4A). Although not shown, the microcontroller 126 communicates commands to the transmission system of Fig. 2 via a wireless channel.

It will be appreciated that, when changing the control variables during the blanking periods, the adaptation process is unnoticed or minimally noticed by the viewer. Changing at other times is possible and is incorporated within the scope of the present invention.

It will be appreciated that the reception system could include an extra antenna-tuning mechanism for the sole purpose of continually testing the received signal. In yet another embodiment, special signals can be transmitted during the blanking periods in order to facilitate the assessment of signal quality.

Reference is now made to Fig. 5 which illustrates a method, performed by the microcontroller 126, for automatically selecting an acceptable picture quality.

Initially (step 130), the quality of the picture is assessed by microcontroller 126. This can be achieved in any of a number of ways, all of which are incorporated into the present invention. In one embodiment, the quality is

measured by the intensity of the sync signals which, unlike the television signals, carry no information thereon and therefore, should have a single intensity level. When the intensity is below a predetermined threshold, the transmission quality is poor. Intensity can be measured by a rectification and averaging circuit, whose output voltage reflects the intensity of the received signal or it can be measured digitally, by the microcontroller 126.

In another embodiment, the quality is defined by the sharpness of the sync pulses, as shown in Fig. 6 to which reference is now made. Fig. 6 shows two exemplary sync pulses 132 and 134, where the first pulse 132 propagated along only one path and the second pulse 134 propagated along many paths. The second pulse 134, in effect, is a collection of many pulses which arrived at slightly different times.

The first pulse 132 is much sharper than the second pulse 134 and this can be measured by their rise times T1 and T2. The rise time T1 of the first pulse 132 is much smaller than that of the second pulse 134. The sharpness of the signal is measured by its rise time. If the rise time is below a predetermined value, the signal quality is high.

The rise time can be measured digitally, or with a measurement unit 135, shown in Fig. 7 to which reference is now briefly made. Measurement unit 135 typically receives the output of the sync separator 124 and provides input to the microcontroller 126. It includes an automatic gain control (AGC) amplifier 180, a high pass filter 182, a rectifier and averager 184 and an analog to digital (A/D) converter 186. The output of the automatic gain control amplifier 180 is the sync signal in its original shape but with a predetermined intensity. The output of the AGC amplifier 180 is then fed into high-pass filter 182, producing a signal whose intensity is a monotonically decreasing function of the rise and fall times of the sync signals.

The outputs of the filter 182 and of the AGC amplifier 180 are fed into rectification and averaging circuit 184, which produces a voltage level that increases as the sharpness of the sync signal increases. This signal is fed back into the gain-control input of the AGC amplifier in order to control its gain such that

the signal level at the output remains generally constant. Details of the method for obtaining a signal at an essentially constant intensity are omitted, since they well known in the art.

The outputs of the rectifier and imager 184 and the gain-control voltage of the AGC amplifier 180 are all sampled by an analog-to-digital converter (ADC) 186 and are fed to the microcontroller 126, described in connection with Fig. 4A, which computes a signal-quality number based on the levels of those signals.

It will be appreciated that the signal quality can also be measured by a combination of intensity and sharpness.

Returning to Fig. 5, if the signal quality is good (step 136), no change will be made during this blanking period (step 138). Otherwise, the microcontroller 126 selects acceptable phase shift and attenuation values for the single or multiple sets of antennas.

The term "acceptable" can have any suitable meaning for this purpose. It can be measured by being above some predetermined threshold, or it can be the most optimal of the entire set of values or it can mean a change of a certain amount from the previous value.

Specifically, in step 142, the phase shift of the currently active antenna(s) is changed by microcontroller 126 in small increments, measuring the quality change resulting from each new phase shift. If the quality is high enough for any of the phase shift values (as checked in step 143), the settings (step 148) are changed by microcontroller 126 to the new phase shift and attenuation values.

Otherwise, once an acceptable value for phase shift has been found, a similar operation is performed (step 144) on the attenuation values.

In step 146, the results are reviewed. If they are above a predetermined quality threshold, then the settings are changed (step 148) to the new phase shift and attenuation values. Otherwise, a new frequency setting is selected (step 150) and the process repeats at step 142. If the quality does not improve once all frequency settings are reviewed, the original settings are maintained.

The picture quality can be measured in another way, as indicated in Fig. 8 to which reference is now briefly made. In this embodiment, the input unit 26

shown in Fig. 1 has a number of buttons 190 thereon with which the user indicates the quality of the signal he or she is seeing. The buttons might indicate lack of "snow", sharpness, etc. In this embodiment, the input unit 26 has two wireless transmitters 192 and 194, where the former transmits input to the computer 10 and the latter transmits the quality information to the television antenna signal processor 20. In this embodiment, the television antenna signal processor 20 does not need to separate out the sync signals.

Alternatively, the input unit 26 can have a single wireless transmitter that transmits to the computer 10 and the latter transmits the user's quality information, in the blanking periods, to the television antenna signal processor 20. Still further, the input unit 26 can transmit to the computer 10 and the PC antenna signal processor 18 could include the microcontroller 126 shown in Fig. 4A. In this embodiment, the PC antenna signal processor 18 transmits the control signals to the television antenna signal processor 20 and the latter does not include the feedback elements of units 120, 121, 124 and 126 shown in Fig. 4A.

It will be appreciated that each combination of locations of computer 10 and television set 12 typically has one direction and polarization which provides the best path from computer 10 to television set 12. The reception processing of the present invention attempts to optimize the effective polarization of the reception antennas but that might not satisfy the user. For example, if the building causes a vertical polarized signal to go through an obstacle that does not let vertical through, there will not be any signal to receive.

If one could find the best path, the signal quality would be much improved.. To take advantage of this, one must also steer the polarization of the transmitted signal rather than merely optimizing the effective polarization of the reception antennas.

Reference is now made to Figs. 9, 10A and 10B which illustrate an alternative embodiment of the transmission and reception systems, respectively, utilizing a transmission antenna 150 which has steerable polarization and to Figs. 11, 12A and 12B which illustrate two embodiments of such a steerable polarization antenna.

As shown in Fig. 9, the transmission system is similar to that of the previous embodiment. In fact, the PC antenna signal processor 152 of this embodiment is essentially the same as PC antenna signal processor 18. However, since steerable polarization antenna 150 is an antenna whose polarization direction can be adaptively changed, the television antenna signal processor of Figs. 10A and 10B, labeled 153, is simplified compared to that of Figs. 4A and 4B. The reception system of Figs. 10A and 10B requires only one set of antennas whose output is provided to the downconverter 90. The television antenna signal processor 153 includes the quality control unit 92 but the control signal is also transmitted, via a wireless channel as discussed hereinabove, to the steerable polarization antenna 150.

Fig. 11 shows one embodiment of the steerable polarization antenna 150. Its input signal is an original signal specified (as a function of time) by the function s(t) and it comprises two antennas 154 and 156 where antenna 154 has horizontal polarization and antenna 156 has vertical polarization, two amplifiers 158 and 159, one per antenna, and an optional phase shifter 160.

The polarization of a signal transmitted by the two antennas 154 and 156 is the vector sum of the output of the two antennas. When input signal s(t) is fed into vertical antenna 156 after being amplified, in amplifier 159, by a constant Kv, and similarly fed into horizontal antenna 154 after being amplified, in amplifier 158, by Kh, the resulting signal, which is the vector sum of the two, has an intensity which is the square root of (Kv^2+Kh^2) and is polarized at an angle defined by the arctangent of (Kv /Kh) relative to horizontal. By controlling the amplification values of amplifiers 158 and 159, the polarization direction can be steered.

Similarly, since the two components are essentially periodic in time, when phase shifter 160 is included, there is a phase shift between the two components and the resulting vector sum rotates in space in a periodic fashion. The vector's tip forms an ellipse, hence the name "elliptical polarization". In the special case wherein the intensities of the two components are equal and their phases differ by 90 degrees, the resulting polarization is circular.

Microcontroller 126 changes the polarization of steerable polarization antenna 150, typically in small steps, to select the polarization direction which provides the best transmission signal.

Figs. 12A and 12B illustrate a different steerable polarization antenna, labeled 150'. This antenna comprises a plurality of first antennas 170 in a first plane 171, a matching plurality of second antennas 172 in a second plane 173 and a selector 174. The antennas 170 and 172 transmit in a different directions. Any combination of one first antenna 170 and one second antenna 172 provides an antenna with a different polarization, where the polarization is the vector sum of the two polarizations.

Selector 174 receives the input signal s(t) and provides it to the currently selected first and second antennas 170 and 172, respectively. Selector 174 chooses the two antennas in accordance with instructions from microcontroller 126.

For both types of steerable polarization antennas 150 and 150', the adjustment sequence involves first setting the transmitted polarization and transmitting the signal. The reception antennas are then adjusted, as described hereinabove with respect to Fig. 5, and the quality level is recorded. The process is repeated for each possible polarization, where, for the steerable polarization antenna 150 of Fig. 11, the values of the phase shift and amplifications are stepped. The microcontroller 126 selects the polarization level to the one which produced the best results and provides the appropriate signals to the steerable polarization antenna 150 or 150' and to the antenna signal processor 84.

It will be appreciated that the combinations of transmission and reception antennas shown herein are not the only combinations possible. For example, the transmission antenna can be a steerable polarization antenna and the reception antenna can be a multiple set antenna such as is shown in Fig. 2. In a further example, the receiver can have a multi-polarization antenna or, if the transmission antenna is a steerable polarization antenna, the receiver can have a single antenna. Any and all of the combinations shown hereinabove are incorporated in the present invention.

The many features and advantages of the present invention are apparent from the written description, and thus, it is intended by the appended claims to cover all such features and advantages of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation as illustrated and described. Hence, all suitable modifications and equivalents may be resorted to as falling within the scope of the invention. By way of example, while the invention was described in the context of the transmission of the screen (and audio) contents of a PC to a television set as an analog composite video signal, it is recognized that with appropriate minor and obvious modifications, the elements of this invention can also be applied to other types of signals.

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described herein above. Rather the scope of the invention is defined by the claims that follow:

CLAIMS

1. A system for providing the output of a computer to a television set via wireless channel within a building, the system comprising:

   a transmission antenna unit;

   a transmission processor connected between said computer and said transmission antenna unit for converting said computer output to a composite video signal, for upconverting said composite video signal to a carrier frequency not within a range reserved for television transmissions and for providing said upconverted signal to said transmission antenna for transmission within said building;

   a reception antenna unit, located away from said transmission antenna unit, having at least one set of two, differently polarized reception antennas for receiving said transmitted signal;

   a reception processor connected between said reception antenna unit and said television set for processing and combining the output of said two transmission antennas of each said at least one set and for adapting said processing in accordance with the quality of said output.

2. A system according to claim 1 and wherein said reception processor includes means for measuring said quality during non-image periods and for adapting said processing when said quality is lower than a predetermined threshold.

3. A system according to claim 1 and wherein said transmission antenna unit is a multi-polarization antenna.

4. A system according to claim 1 and wherein said reception antenna unit is a multi-polarization antenna.

5. A system according to claim 1 and wherein said transmission antenna unit is an antenna with steerable polarization, said transmission antenna includes:

a first antenna polarized in a first direction which directly transmits said upconverted signal;

a controllable processor which provides at least one of amplification and phase shifting to said upconverted signal; and

a second antenna polarized in a second direction other than said first direction which transmits the output of said processor,

wherein the amount of said phase shift and amplification can be changed thereby to change the polarization direction of the combined signal transmitted together by the first and second antennas.

6. A system according to claim 1 and wherein said transmission antenna unit is an antenna with steerable polarization, said transmission antenna includes:

a multiplicity of first antennas lying in a first plane, wherein each first antenna has a different polarization direction within said first plane;

a multiplicity of second antennas lying in a second plane, wherein each second antenna has a different polarization direction within said second plane; and

a selector for selecting one of said first antennas and one of said second antennas thereby to define a polarization direction and for transmitting said upconverted signal through said selected first and second antennas.

7. A system according to claim 1 and wherein said reception processor includes:

one adaptable antenna processing unit per set of reception antennas, wherein each said antenna processing unit includes a control unit for controlling at least one of the relative phase shift and relative attenuation between the outputs of said set of reception antennas and a combiner for combining the processed outputs of said set of reception antennas;

a downconverter for converting the output of at least one of said combiners to a television signal to be provided to said television set; and

a quality feedback unit for measuring the quality of said television signal and for selecting control values for said control unit accordingly.

8. A system according to claim 7 and wherein said one antenna processing unit per set of reception antennas is two antenna processing units and wherein said reception processor includes a combiner for combining the output of said antenna processing units.

9. A system according to claim 7 and wherein said one antenna processing unit per set of reception antennas is two antenna processing units and wherein said reception processor includes a selector for selecting one the outputs of said antenna processing units.

10. A system according to claims 6 and 7 wherein said quality feedback unit also selects control values for said selector and also including a wireless control unit for transmitting said selector control values to said transmission processor.

11. A system according to claims 5 and 7 wherein said quality feedback unit also selects control values for said controllable processor and also including a wireless control unit for transmitting said processor control values to said transmission processor.

12. A system according to claim 7 and wherein said quality feedback unit comprises input units for receiving quality definitions from a user.

13. A reception unit for a system which transmits the output of a computer to a television set via wireless channel within a building, the reception unit comprising:

a reception antenna unit having at least one set of two, differently polarized reception antennas for receiving the transmitted output of said computer;

a reception processor connected between said reception antenna unit and said television set for processing and combining the output of said two antennas of each said at least one set and for adapting said processing in accordance with the quality of said output.

14. A reception unit according to claim 13 and wherein said reception processor includes means for measuring said quality during non-image periods and for adapting said processing when said quality is below a predetermined threshold.

15. A reception unit according to claim 13 and wherein said reception processor includes:

one adaptable antenna processing unit per set of reception antennas, wherein each said antenna processing unit includes a control unit for controlling at least one of the relative phase shift and relative attenuation between the outputs of said set of reception antennas and a combiner for combining the processed outputs of said set of reception antennas;

a downconverter for converting the output of at least one of said combiners to a television signal to be provided to said television set; and

a quality feedback unit for measuring the quality of said television signal and for selecting control values for said control unit accordingly.

16. A system according to claim 15 and wherein said one antenna processing unit per set of reception antennas is two antenna processing units and wherein said reception processor includes a combiner for combining the output of said antenna processing units.

17. A system according to claim 15 and wherein said one antenna processing unit per set of reception antennas is two antenna processing units and wherein said reception processor includes a selector for selecting one the outputs of said antenna processing units.

18. A system according to claim 15 and wherein said quality feedback unit comprises input units for receiving quality definitions from a user.

19. A system according to claim 13 and wherein said reception antenna unit is a multi-polarization antenna.

20. A transmission antenna with steerable polarization, the antenna comprising:

a first antenna polarized in a first direction which directly transmits an upconverted signal;

a controllable processor which provides at least one of amplification and phase shifting to said upconverted signal; and

a second antenna polarized in a second direction other than said first direction which transmits the output of said processor,

wherein the amount of said phase shift and amplification can be changed thereby to change the polarization direction of the

combined signal transmitted together by the first and second antennas.

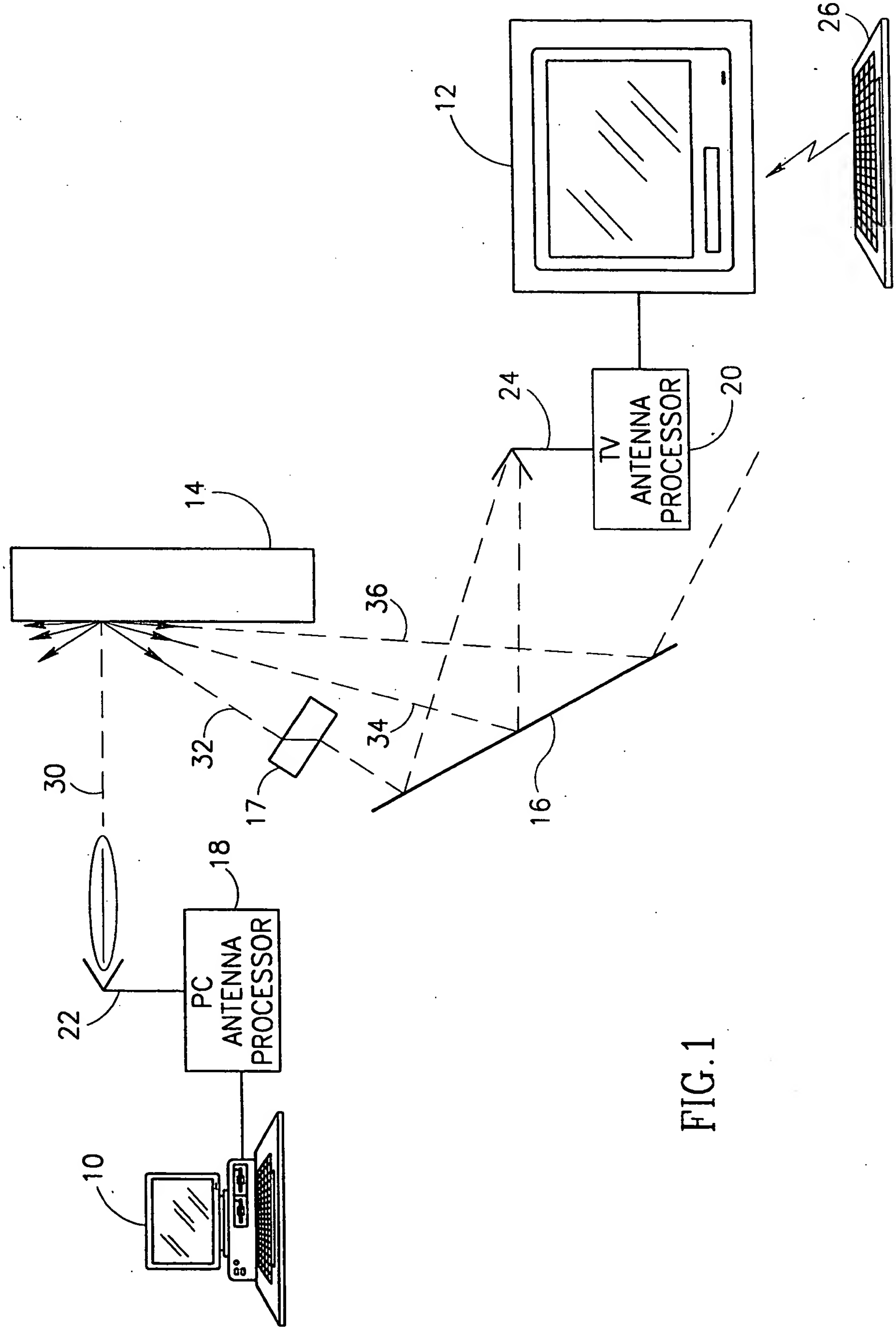
21. A transmission antenna with steerable polarization, the antenna comprising:

a multiplicity of first antennas lying in a first plane, wherein each first antenna has a different polarization direction within said first plane;

a multiplicity of second antennas lying in a second plane, wherein each second antenna has a different polarization direction within said second plane; and

a selector for selecting one of said first antennas and one of said second antennas thereby to define a polarization direction and for transmitting an upconverted signal through said selected first and second antennas.

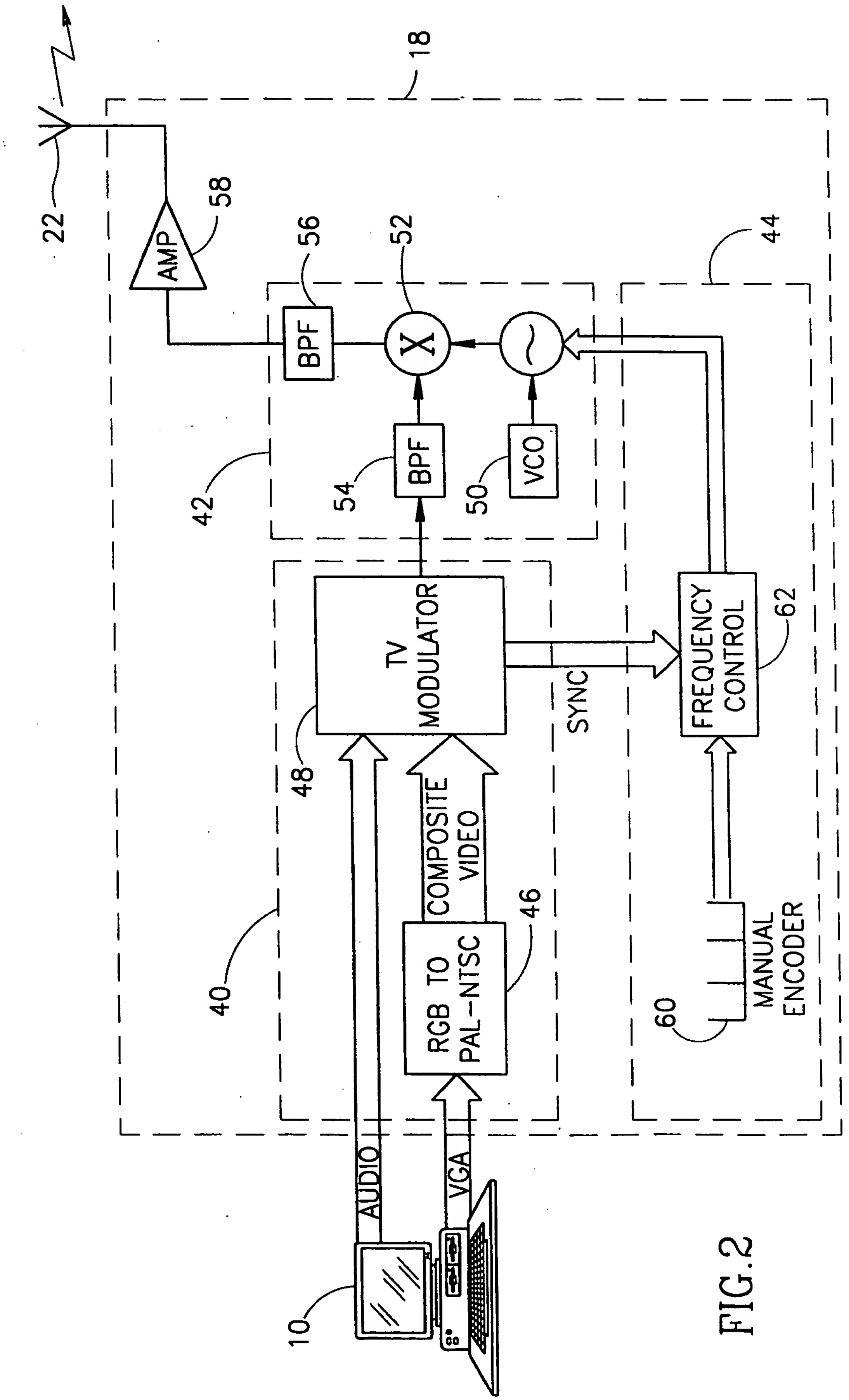
1/11



12
26
24
20
TV
ANTENNA
PROCESSOR
14
36
34
32
30
17
16
18
PC
ANTENNA
PROCESSOR
22
10

FIG.1

2/11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AMP
58
BPF
56
X
52
BPF
54
VCO
50
42
44
TV
MODULATOR
48
SYNC
FREQUENCY
CONTROL
62
COMPOSITE
VIDEO
RGB TO
PAL-NTSC
46
40
MANUAL
ENCODER
60
AUDIO
VGA
10

FIG.2

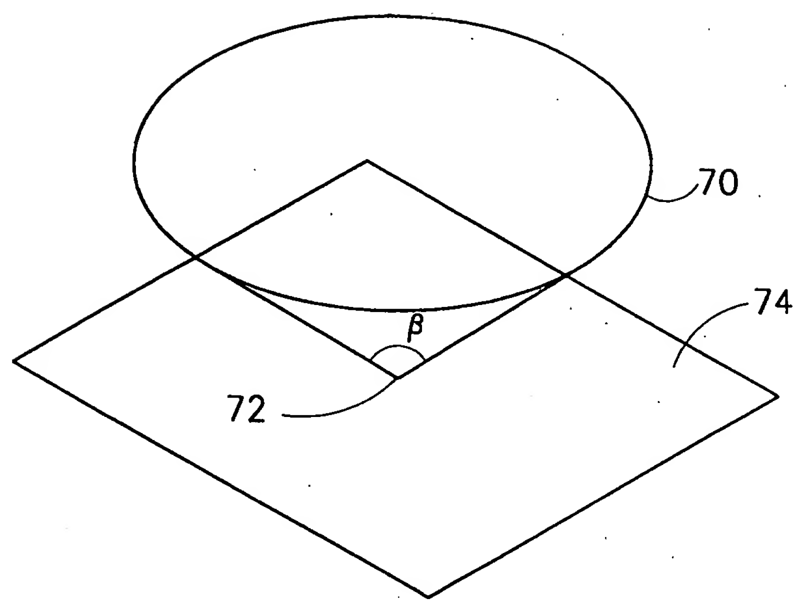

FIG.3

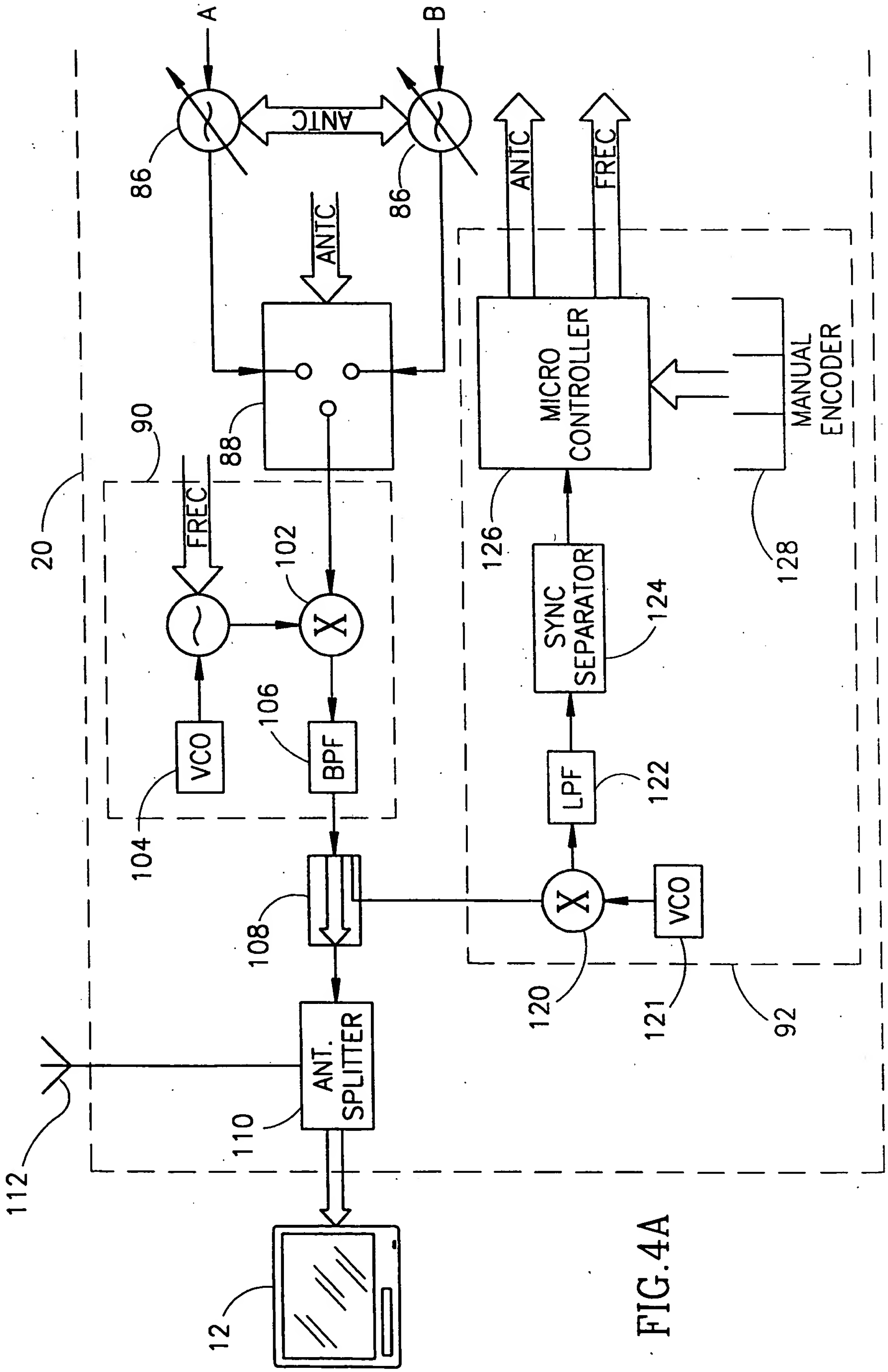
A
B
ANTC
86
86
ANTC
ANTC
FREC
FREC
88
90
20
MICRO CONTROLLER
MANUAL ENCODER
126
128
SYNC SEPARATOR
124
102
VCO
104
BPF
106
LPF
122
108
VCO
120
121
92
ANT. SPLITTER
110
112
12

FIG.4A

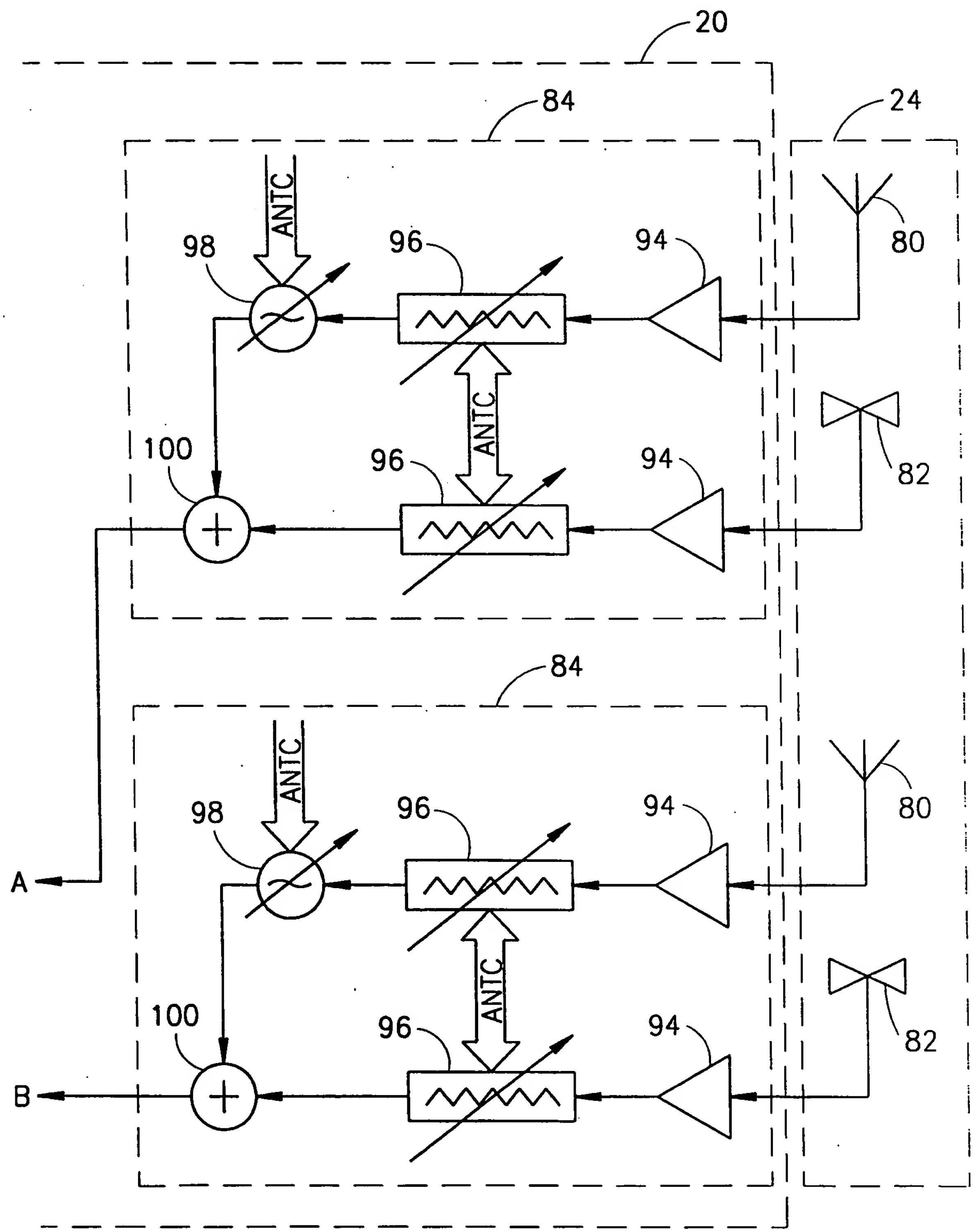
20
84
24
ANTC
98
96
94
80
ANTC
82
100
96
94
84
ANTC
98
96
94
80
A
ANTC
82
100
96
94
B

FIG.4B

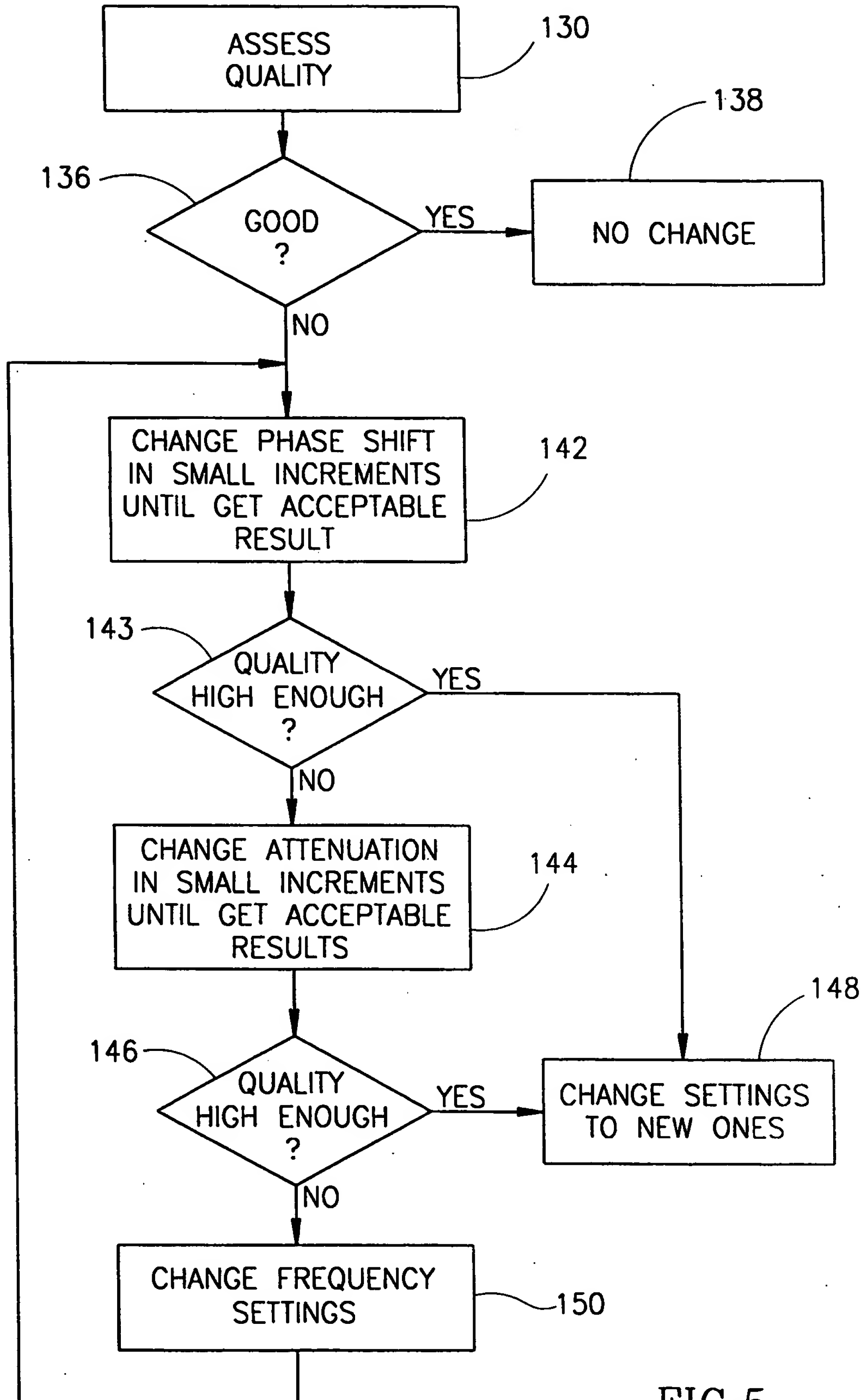
ASSESS QUALITY
130
138
136
GOOD ?
YES
NO CHANGE
NO
CHANGE PHASE SHIFT IN SMALL INCREMENTS UNTIL GET ACCEPTABLE RESULT
142
143
QUALITY HIGH ENOUGH ?
YES
NO
CHANGE ATTENUATION IN SMALL INCREMENTS UNTIL GET ACCEPTABLE RESULTS
144
148
146
QUALITY HIGH ENOUGH ?
YES
CHANGE SETTINGS TO NEW ONES
NO
CHANGE FREQUENCY SETTINGS
150

FIG.5

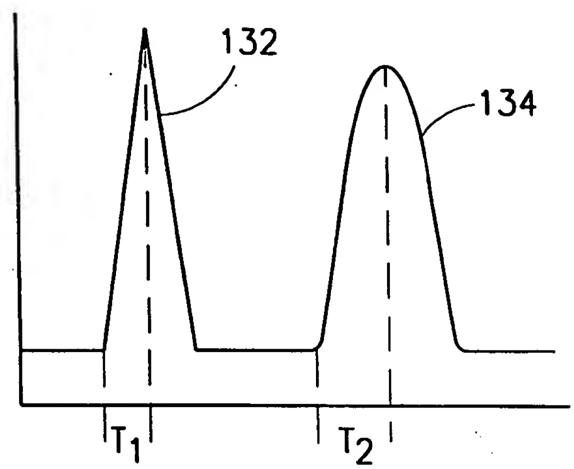

FIG.6

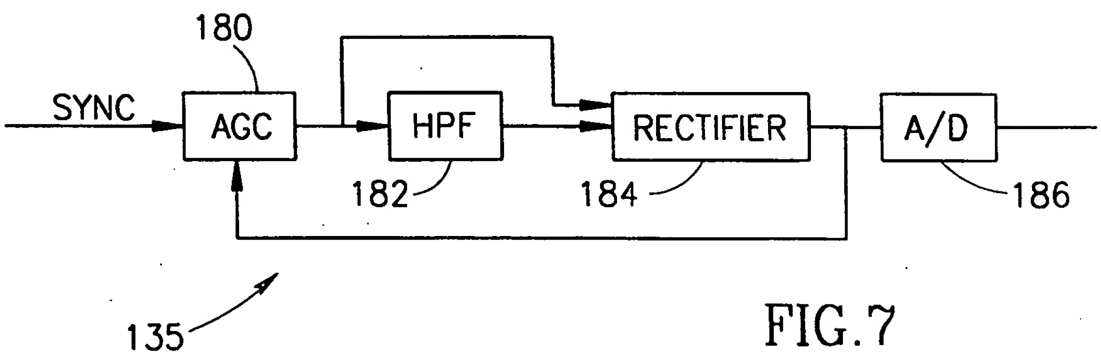

FIG.7

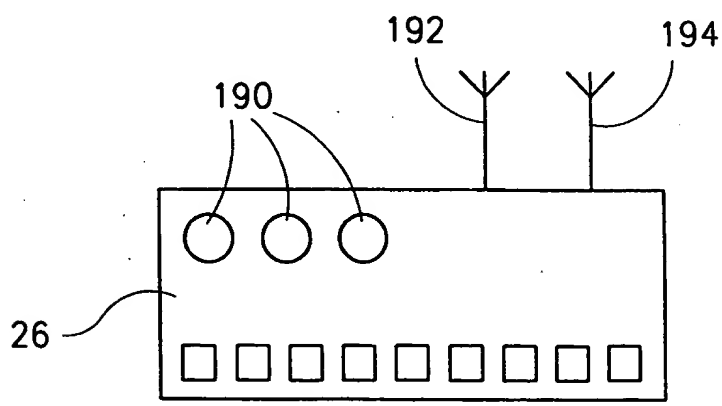

FIG.8

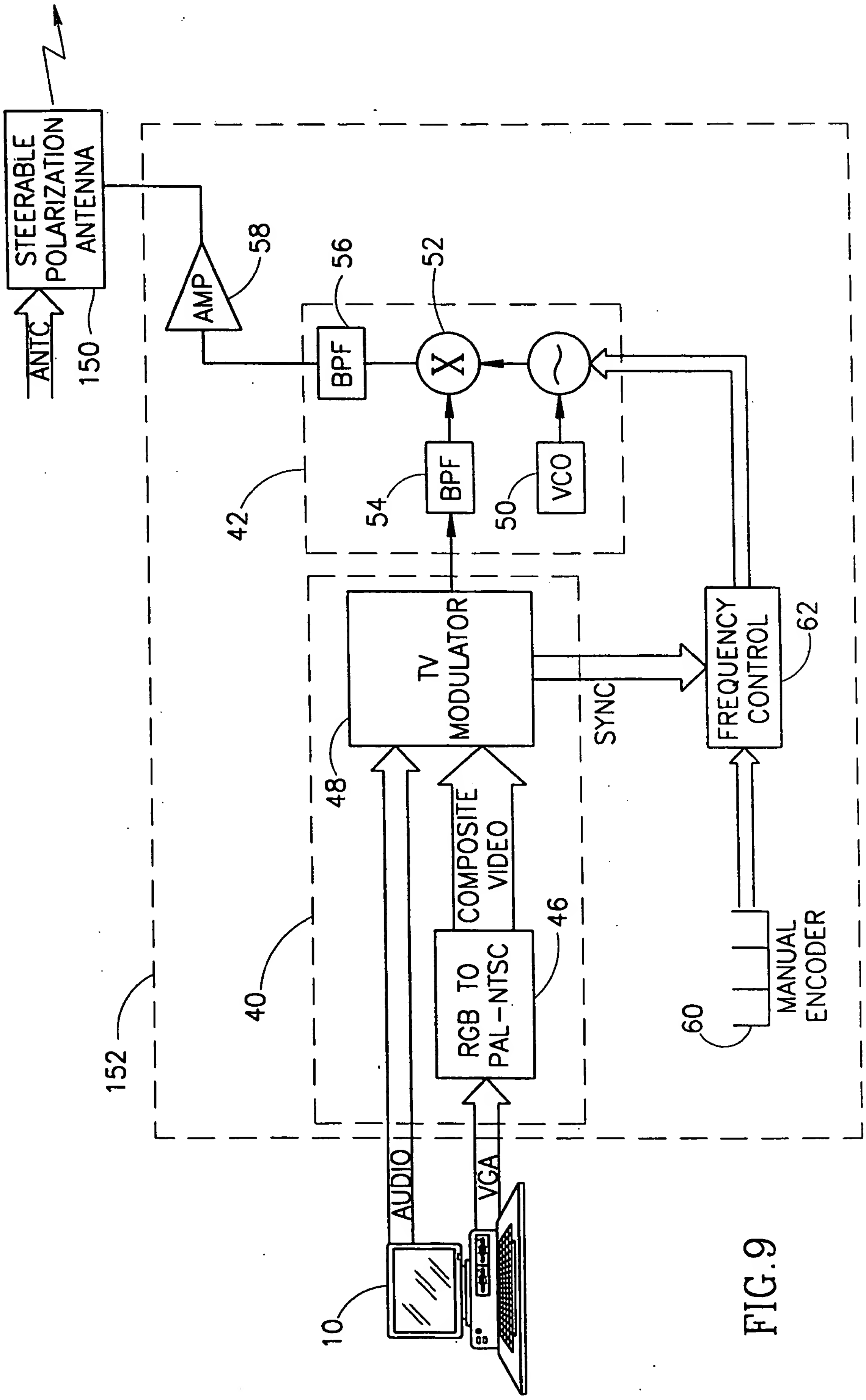
STEERABLE POLARIZATION ANTENNA
ANTC
150
AMP
58
BPF
56
52
X
BPF
54
VCO
50
42
TV MODULATOR
48
SYNC
FREQUENCY CONTROL
62
COMPOSITE VIDEO
RGB TO PAL-NTSC
46
40
152
MANUAL ENCODER
60
AUDIO
VGA
10

FIG.9

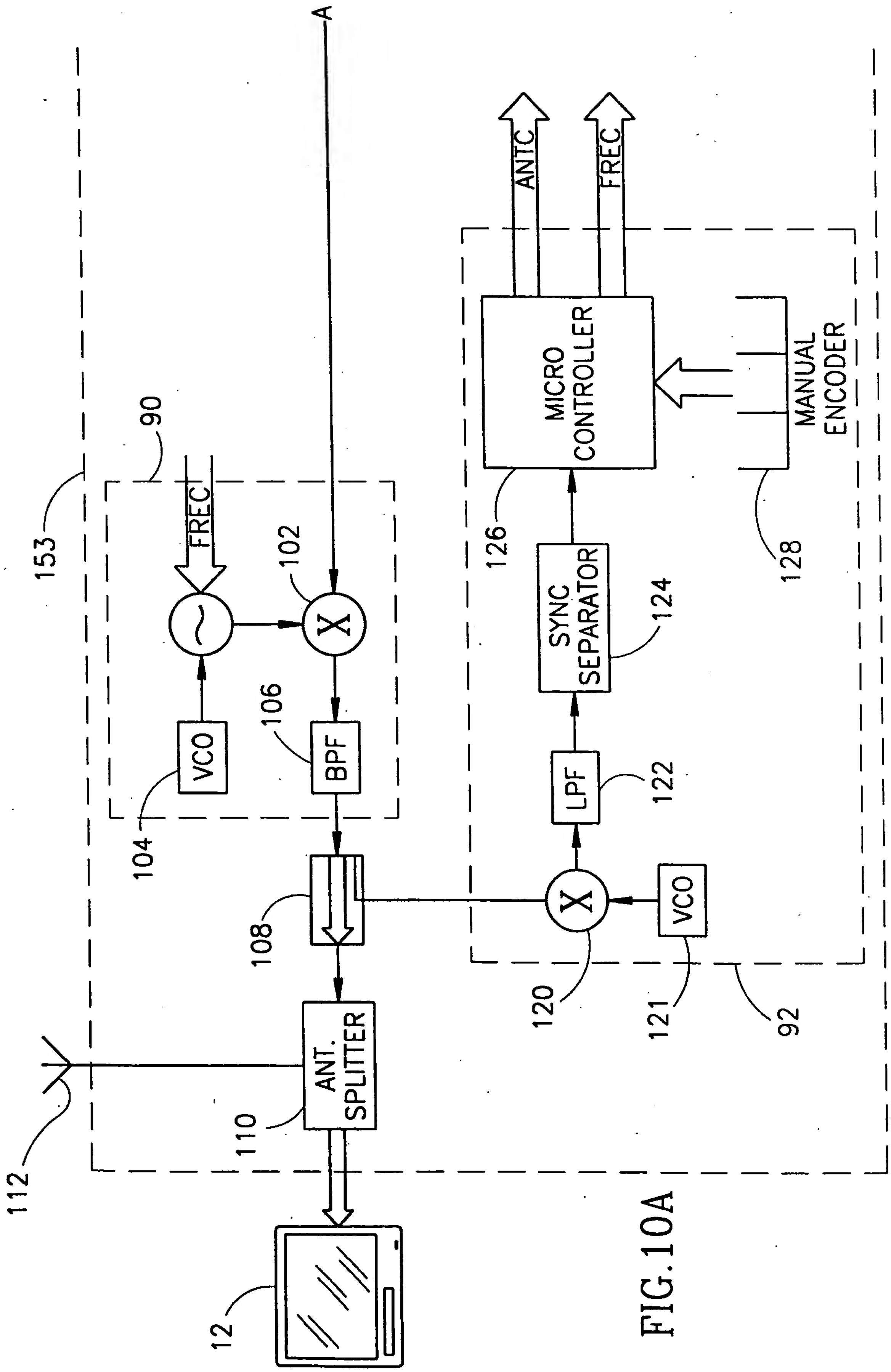
A
ANTC
FREC
MICRO CONTROLLER
MANUAL ENCODER
153
90
FREC
102
X
VCO
BPF
106
104
126
SYNC SEPARATOR
124
128
LPF
122
108
X
VCO
120
121
92
ANT. SPLITTER
110
112
12

FIG.10A

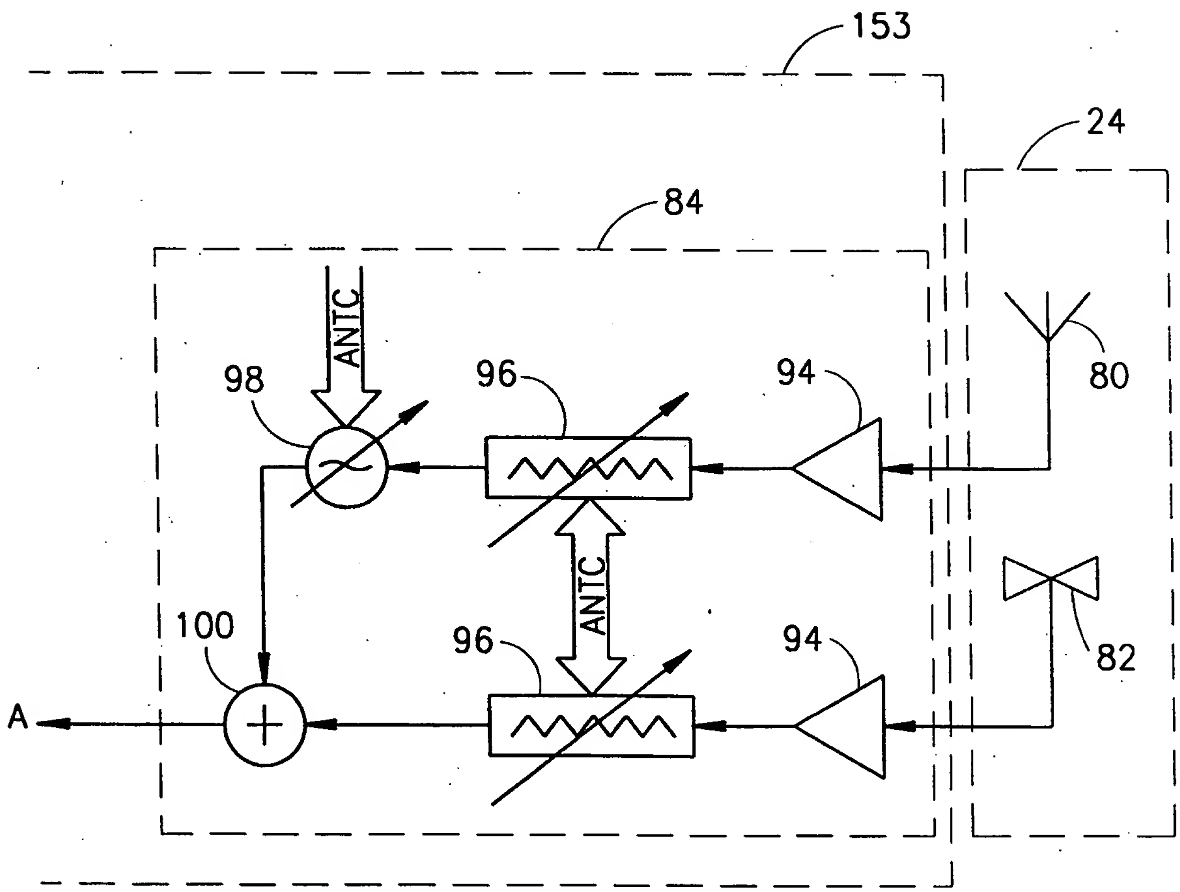

FIG.10B

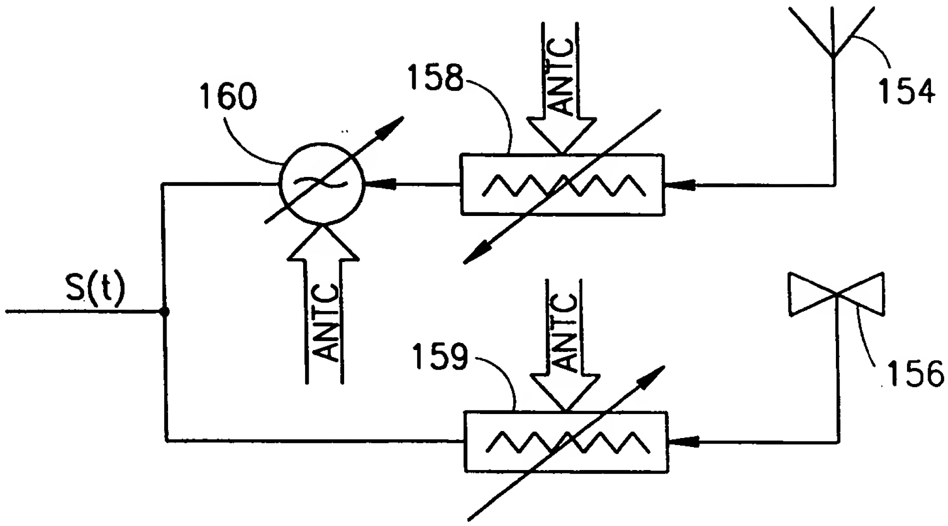

FIG.11

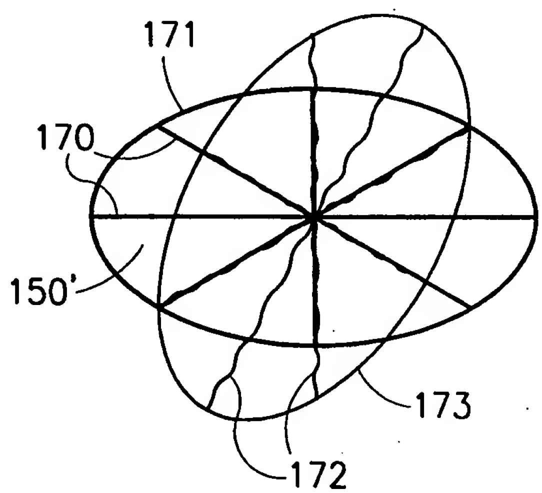

FIG.12A

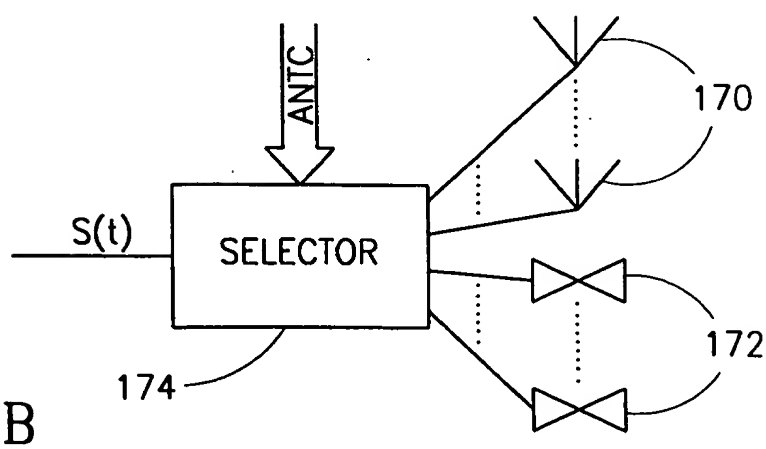

FIG.12B